

**EMERGENCY STRUCTURAL ASSESSMENT
OF
EARTHQUAKE DAMAGE TO KAILUA - KONA WHARF
LOCATED AT
KAILUA - KONA, HAWAII

PREPARED FOR
THE STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF BOATING AND OCEAN RECREATION
HONOLULU, HAWAII 96813**



THIS WORK WAS PREPARED BY ME
OR UNDER MY SUPERVISION.

Arnold T. Okubo
SIGNATURE

PREPARED BY

**ARNOLD T. OKUBO & ASSOCIATES, INC.
94-529 UKEE STREET, SUITE 107
WAIPAHU, HAWAII 96797**

NOVEMBER 2006

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ESTIMATE TO REPAIR EARTHQUAKE DAMAGES TO KAILUA - KONA WHARF
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I. INTRODUCTION

The purpose of this report is to evaluate and assess the structural damages caused by the October 15, 2006 earthquake of magnitude 6.7.

II. SUMMARY

Underwater Inspection/Assessment:

The underwater inspection of the existing steel sheet pile bulkhead wall ascertain that there were damages to the steel sheet pile concrete cap. The concrete cap (2'-2" thick by 9'-6" deep) which protect the steel sheet pile from corrosion have vertical cracks throughout along the length of sheet pile bulkhead wall. The vertical cracks run from the top of the cap to the bottom of the cap. There are numerous areas of the sheet pile surface face that the surface rust and marine growth had fallen off due to the bending and movement of the steel sheet pile. The cracks at the concrete cap are recommended to be repaired as soon as possible. The concrete cap supports and strengthens the top of the sheet pile bulkhead with a tie back system and the cap also protects the steel sheet pile and reinforcing bars from salt water corrosion.

Above water Inspection/Assessment:

The 6" thick concrete slab on grade has extensive cracks throughout. The concrete slab shows many signs of distress such as random cracks up to 3/32" wide. These cracks were caused by the recent earthquake. The asphaltic concrete pavement also has cracks caused by the earthquake. Also observed were earthquake associated cracks at the boat launching ramp, concrete rubble masonry (CRM), stairways, boat landing areas and walkways. The cracks are recommended to be repaired to restore the structural integrity of the wharf, to stop the reinforcing bar corrosion, and to prevent tripping hazards for pedestrians.

The order of magnitude estimated design and construction cost estimate to repair earthquake damages are \$ 1,465,000.00.

III. SCOPE OF WORK

The work involves the following:

1. Conduct an above water investigation/inspection by a licensed structural engineer to determine and assess the structural damages on the wharf surfaces caused by the recent earthquake on October 15, 2006.
2. Conduct an underwater investigation/inspection by a licensed structural engineer to determine and assess the structural damages caused by the recent earthquake to the steel sheet pile bulkhead and CRM revetment wall.
3. Provide a report on the findings.
4. Make recommendations to repair the earthquake damages.
5. Provide a 0% design order of magnitude estimated design and construction cost estimate to repair earthquake damages.

IV. SITE DESCRIPTION OF KAILUA - KONA WHARF

1. Description:

The Kailua - Kona Wharf is located in Kailua, Kona, Hawaii. The wharf extends approximately 600 ft. outward from land towards the ocean. The wharf construction consists of a steel sheet pile bulkhead wall. The bulkhead wall is anchored to a tie rod and concrete deadman anchor system. The area behind the bulkhead wall has backfill material and a concrete slab on grade at the finish surface. The sheet pile bulkhead has a 2'-2" wide by 9'-6" deep concrete cap between elevation +6.50 and elevation -3.00.

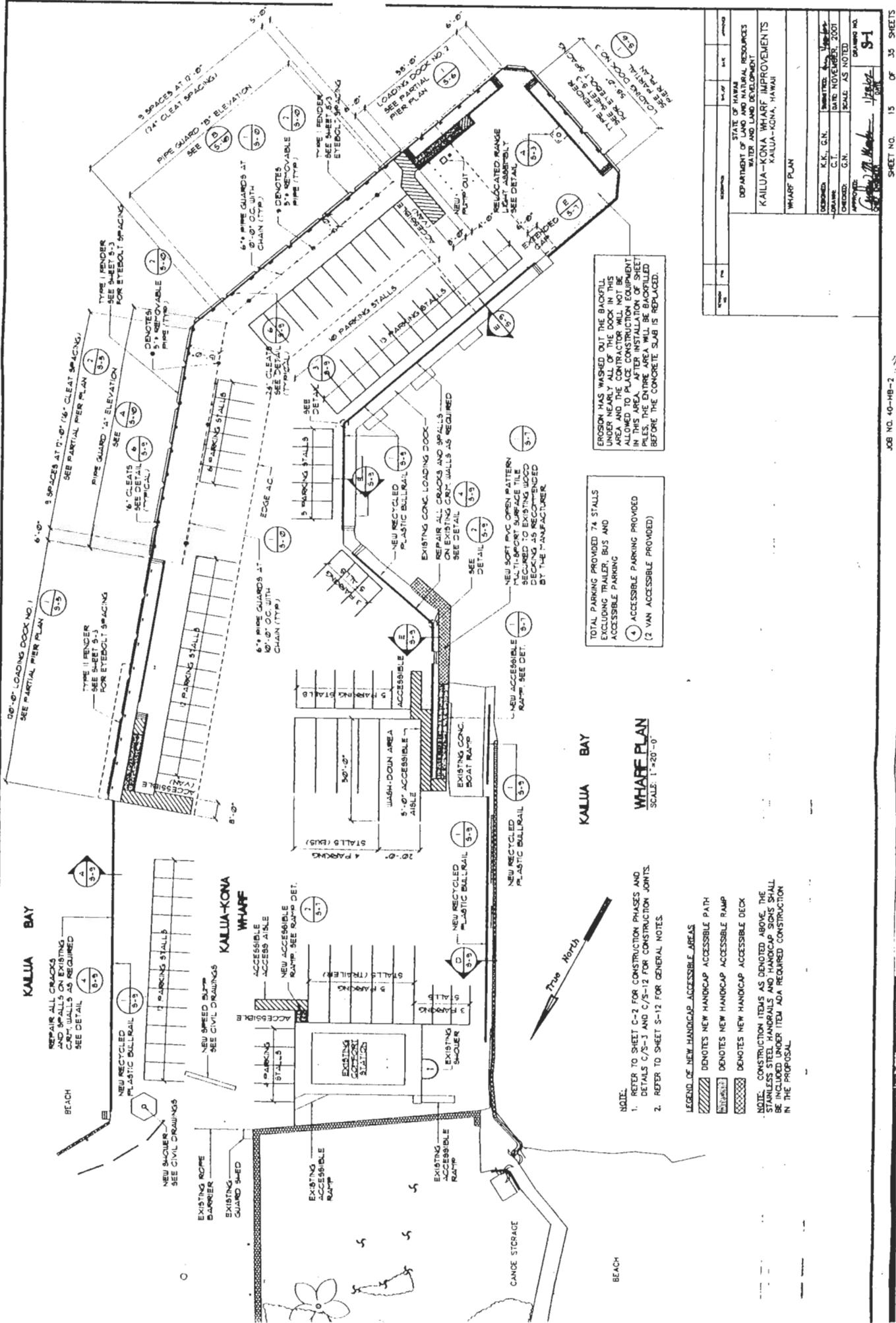
The Kailua - Kona Wharf most recent improvements were completed in the year 2004. The improvements included new 575 L.F. of steel sheet pile bulkhead with concrete cap, concrete and asphaltic concrete pavement, pavement striping, utilities (water lines, drain lines, sewer lines, area lighting), loading docks, ADA accessible ramps, pipe guards, mooring cleats and fenders, bullrails, and a fish scale.

2. Function of the Facility:

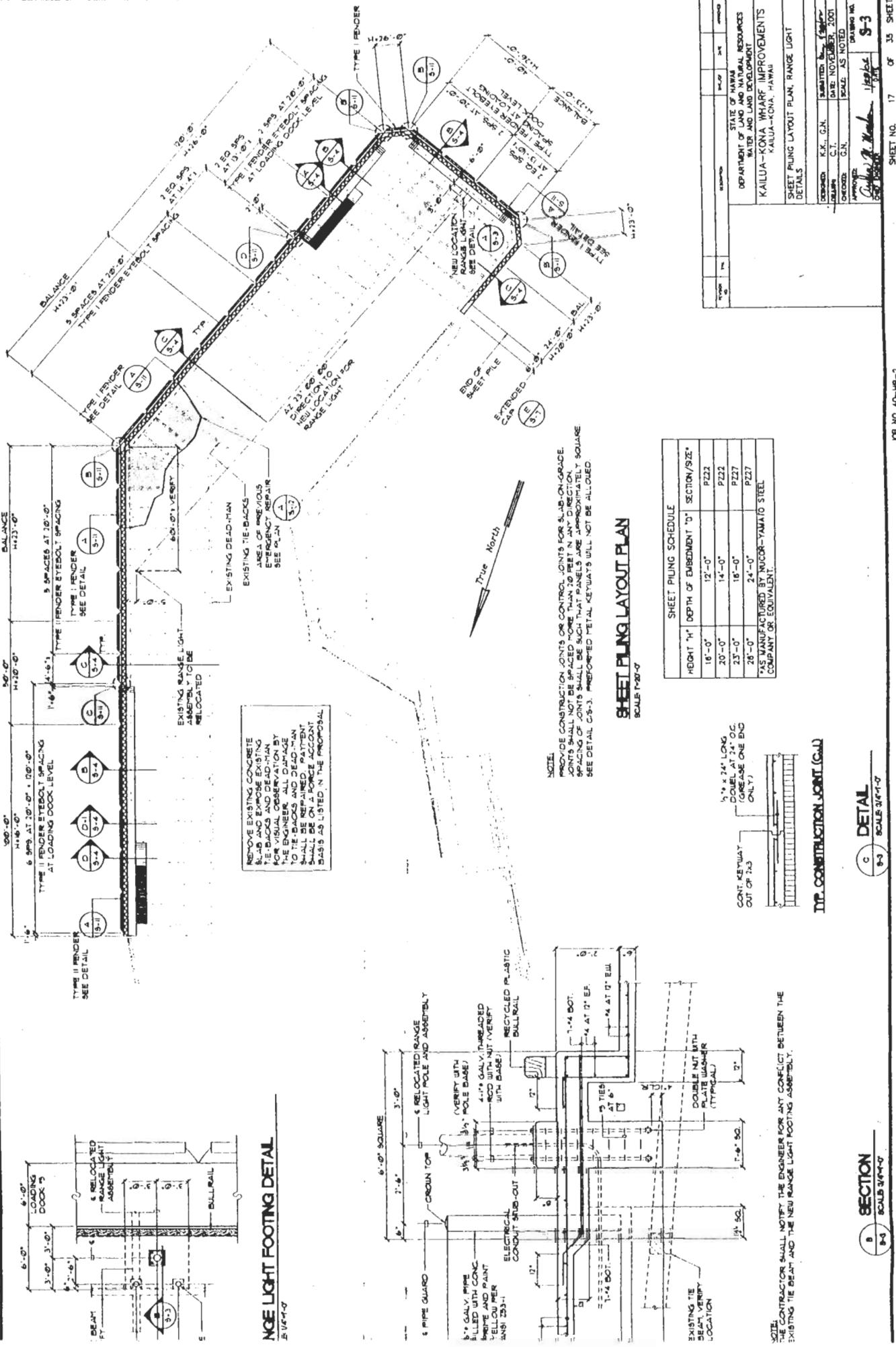
The wharf is primarily used to load and off load passengers of small vessels.

EXISTING KAILUA-KONA WHARF

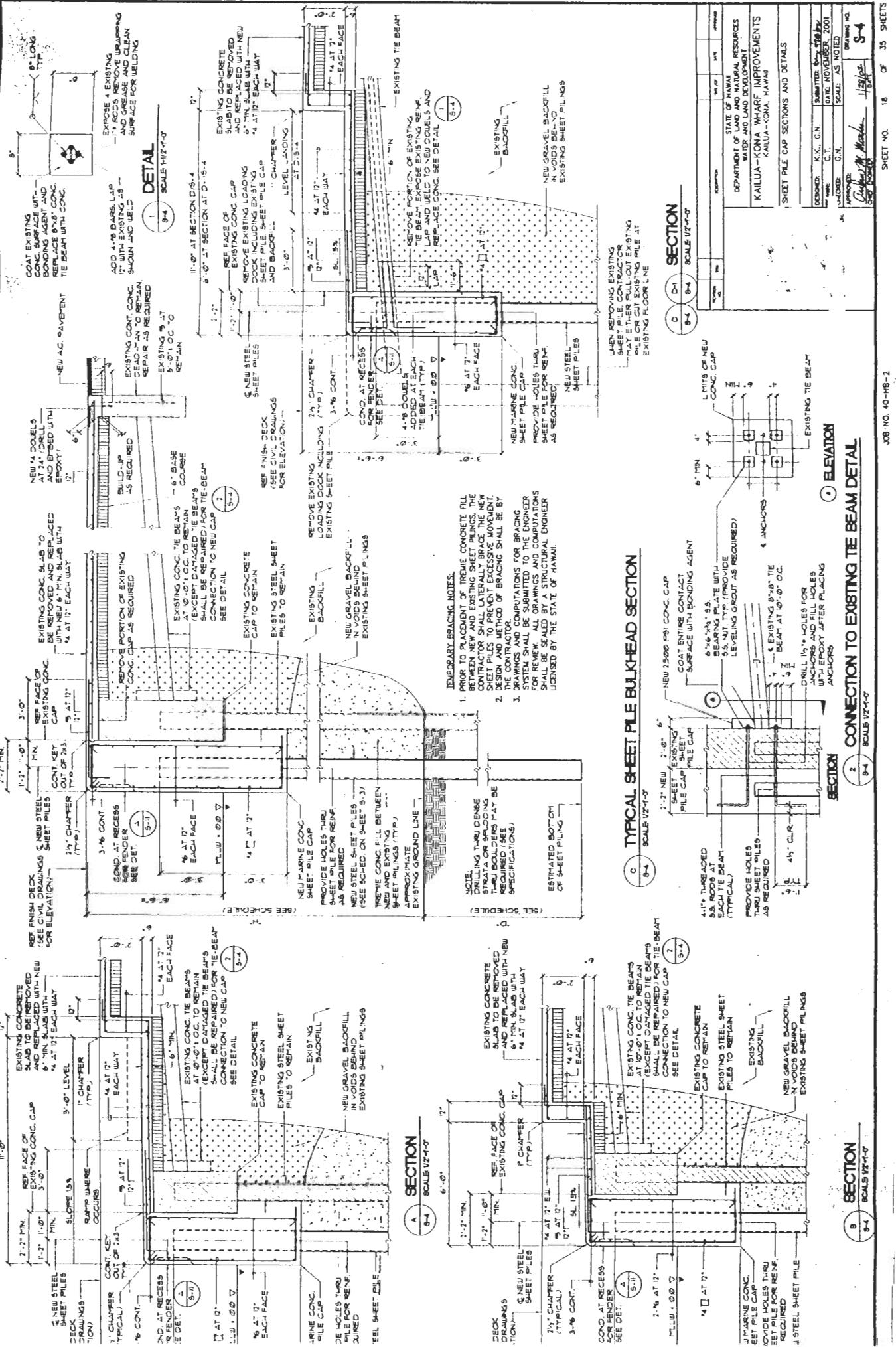
PLANS AND SECTIONS

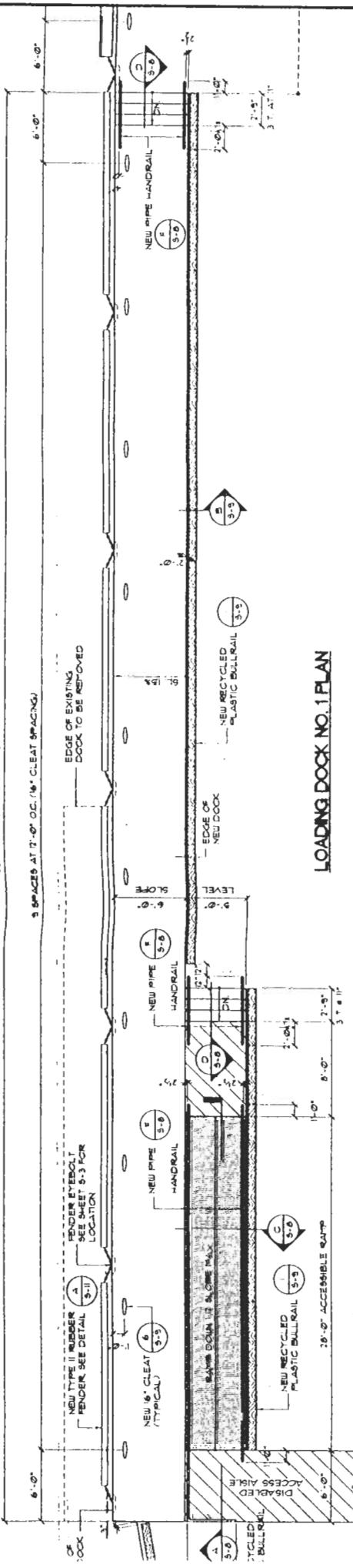


SHEET NO. 15 OF 25 SHEETS



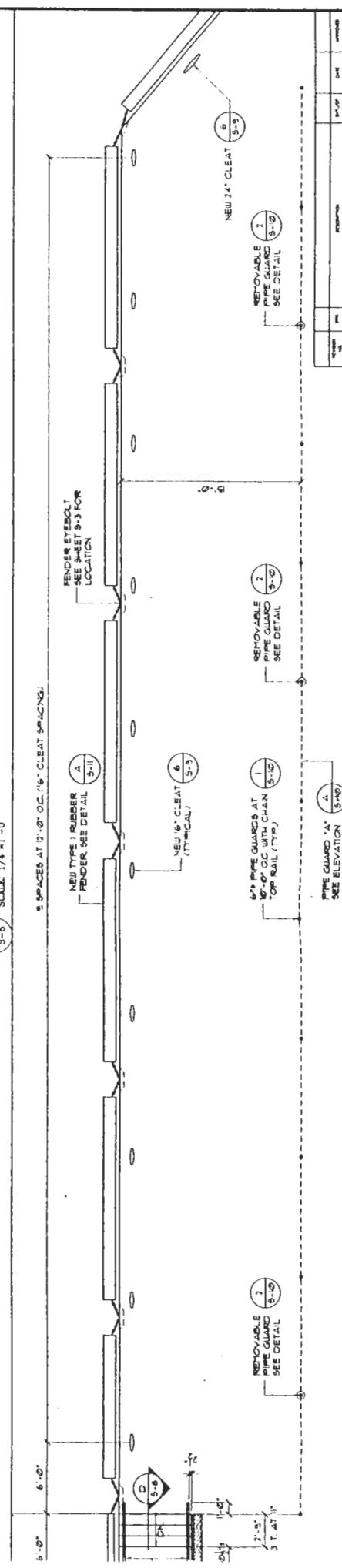
NCE LIGHT FOOTING DETAIL





LOADING DOCK NO. 1 PLAN

PARTIAL PER PLAN



2 PARTIAL PER PLAN

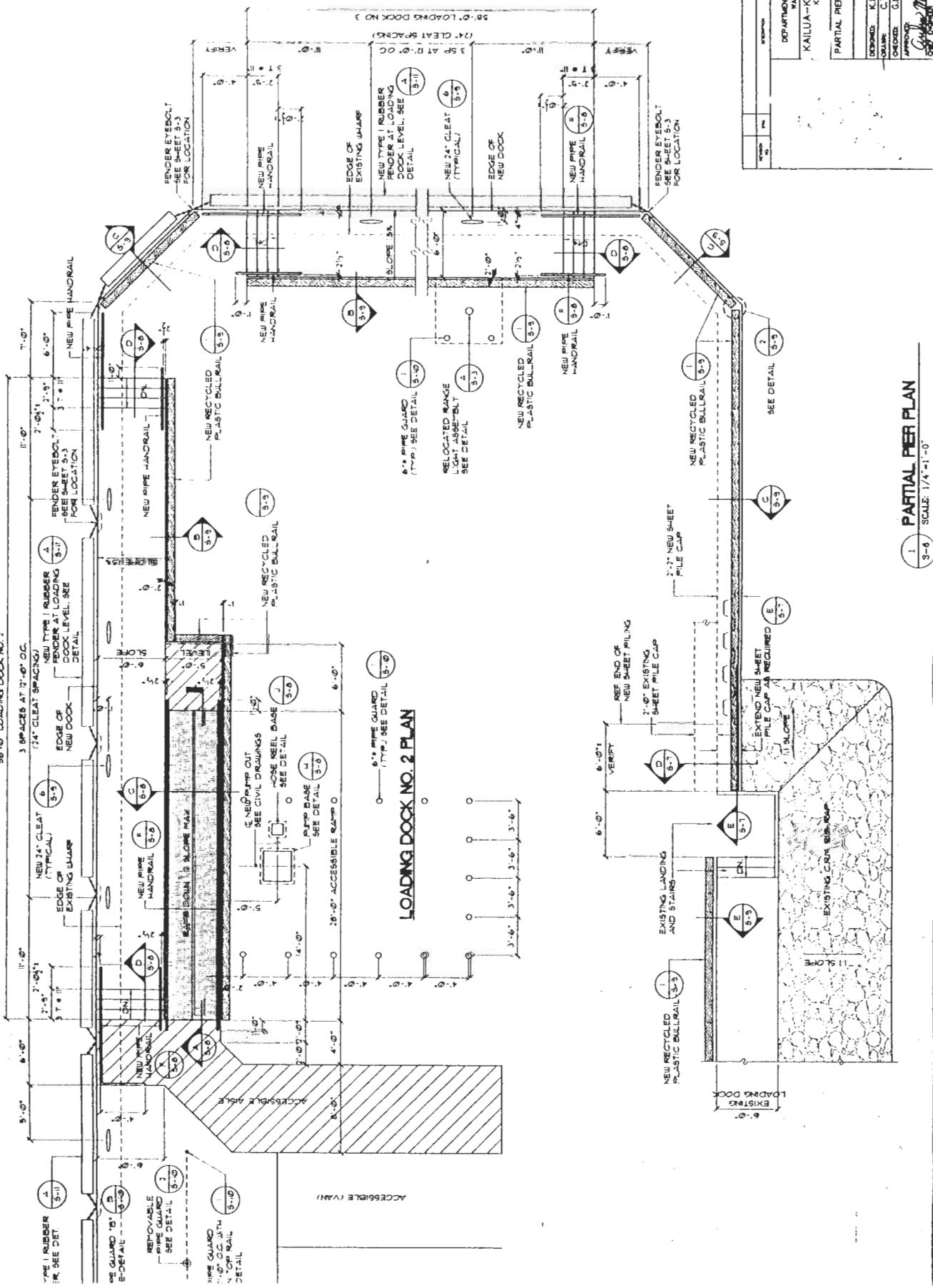
INSTRUMENT	STATE OF HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES WATER AND LAND DEVELOPMENT KAILUA-KONA WHARF IMPROVEMENTS KAILUA-KONA, HAWAII	SEARCHED <i>by [initials]</i> INDEXED <i>by [initials]</i> FILED <i>by [initials]</i>	
SERIAL NO.	14-8	SEARCHED INDEXED FILED	
DATE	12-14-01	DATE	NOVEMBER 2001
OWNER	K.K. G.N. T.D.W. C.T.	SCALE	AS NOTED
CONTRACTOR	G.H.N.	RECORDED	NOVEMBER 2001
PARTIAL PIER PLANS			

SHEETS OF 80 LEAVES

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JOB NO. 40-HB-2

LOADING DOCK NO. 3 PLAN



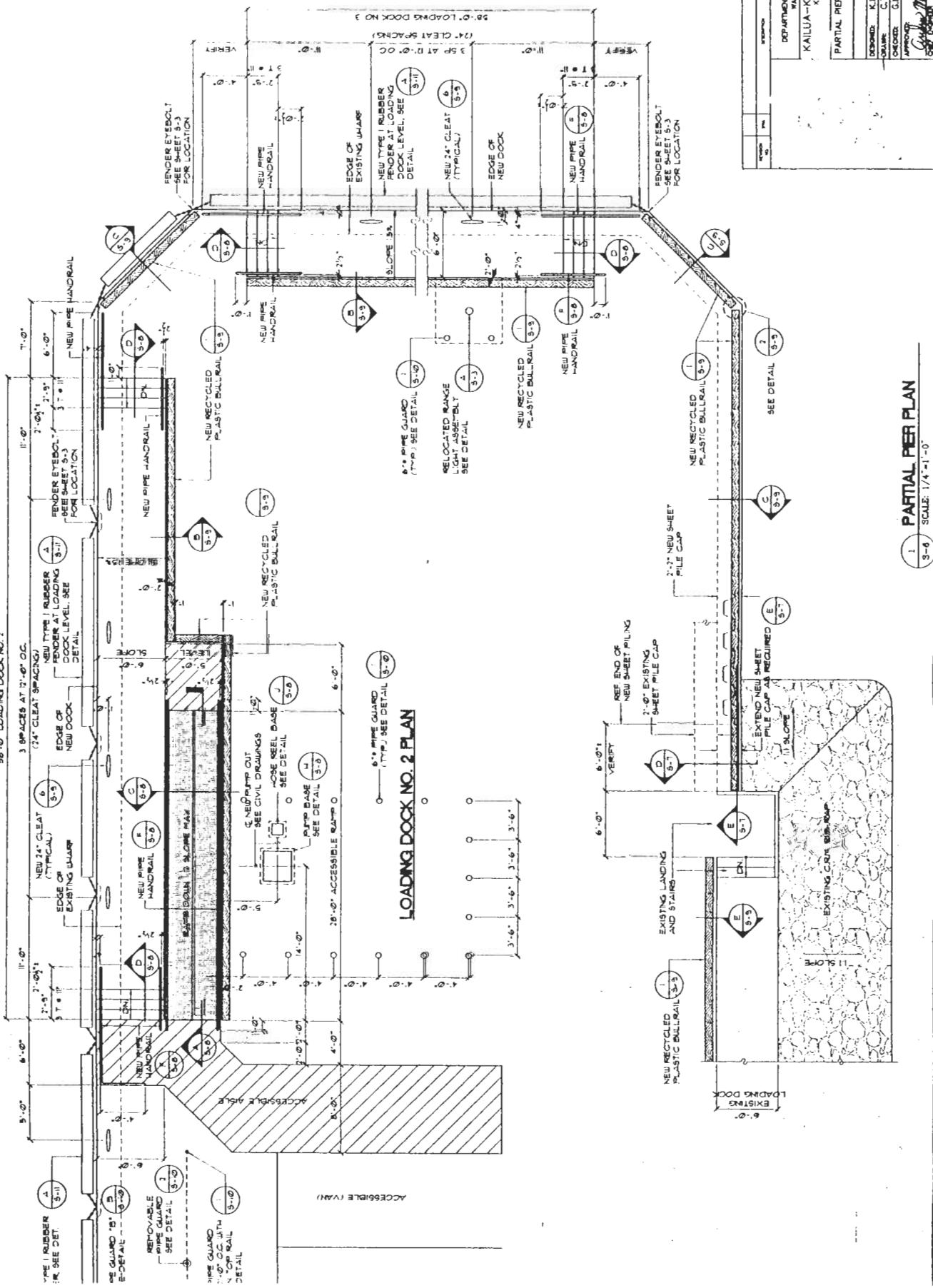
JOB NO. 40-HB-2

SCALE: 1/4"-1'-0"

PARTIAL PIER PLAN

SHEET NO. 20 OF 35 SHEETS

LOADING DOCK NO. 2 PLAN



JOB NO. 40-HB-2

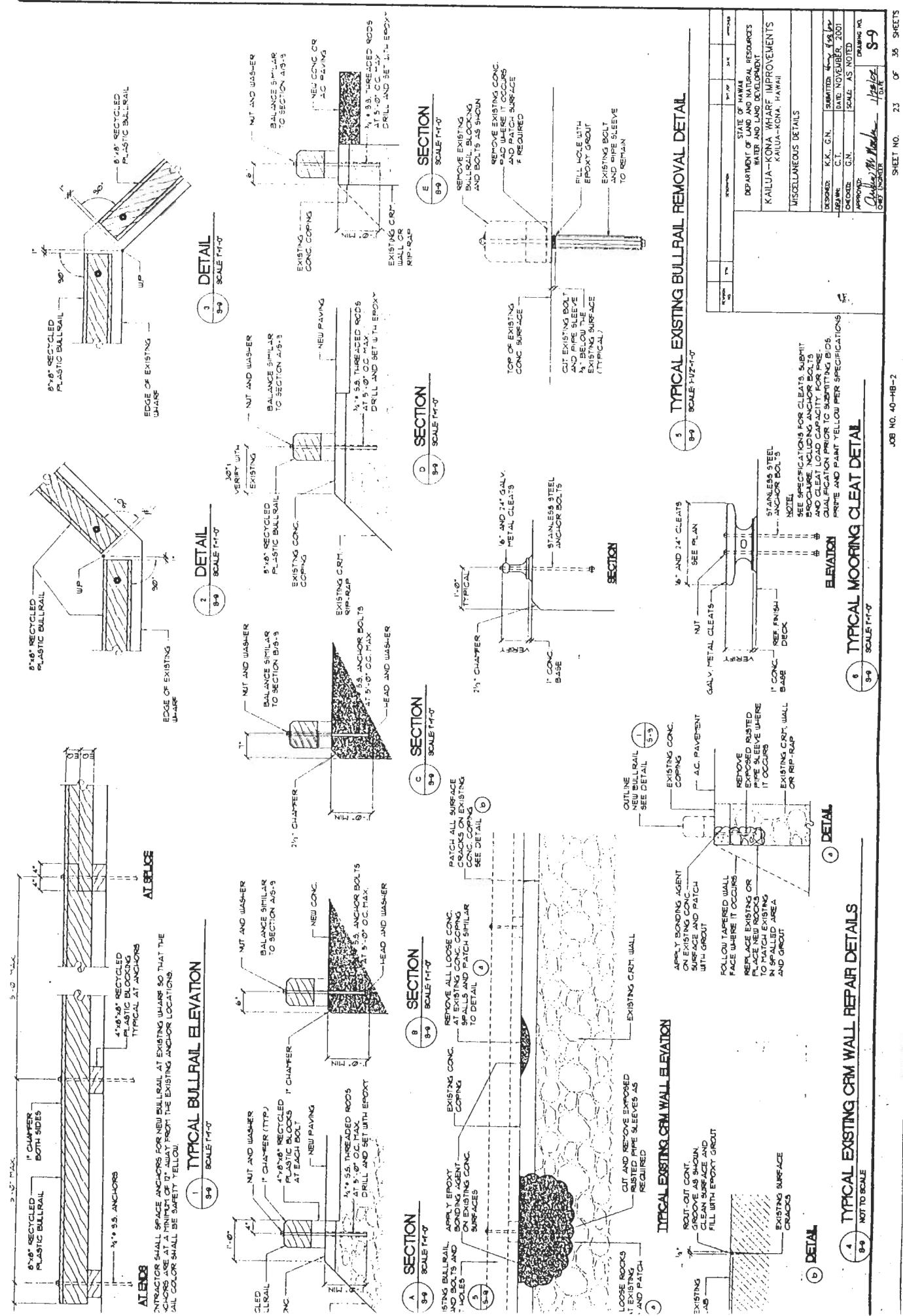
SCALE: 1/4"-1'-0"

PARTIAL PIER PLAN

SHEET NO. 20 OF 35 SHEETS

DEPARTMENT	SECTION	REVISION	DATE	SCALE	DRAWING NO.
DEPARTMENT OF LAND AND NATURAL RESOURCES WATER AND LAND DEVELOPMENT	KAILUA-KONA WHARF IMPROVEMENTS KAILUA-KONA, HAWAII	C.I.	NOVEMBER, 2001	G.N.	8-6

DEPARTMENT	SECTION	REVISION	DATE	SCALE	DRAWING NO.
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1

Kailua-Kona Wharf -
South End (Looking South)



2

Kailua-Kona Wharf Boat Launching Ramp -
North West Side (Looking North)



3

Kailua-Kona Wharf
Wharf Parking Area (Looking North)



4

Kailua-Kona Wharf
Wharf Parking Area (Looking North)



5

Wharf - East Side (Looking South East)



6

Loading Dock No. 2 -
East Side (Looking North)



7

Wharf - East Side (Looking North)



8

Wharf - South East Side at
Loading Dock No. 2 (Looking East)

V. AREA AND METHOD OF INVESTIGATION

1. Underwater Investigation:

An underwater inspection of approximately 575 L.F. of steel sheet pile bulkhead was conducted on October 24, 2006. A careful examination of the steel sheet pile by a licensed structural engineer/diver is essential for an accurate structural assessment of the earthquake damage so that a realistic evaluation can be made. SCUBA equipped licensed structural engineer/diver was used for the inspection. Steel sheet piles were visually inspected from the waterline down to the mudline for damage and failure.

A digital camera with an underwater housing was used to document the existing condition and damage of the steel sheet pile bulkhead. A SCUBA equipped licensed structural engineer/diver inspected and evaluated the steel sheet pile damages underwater. Also, one (1) licensed civil engineer/diver assisted the structural engineer/diver during the underwater structural assessment.

2. Above water Investigation:

An above water structural assessment of the wharf was conducted on October 24, 2006. The top deck surface was inspected for visual symptoms of cracking, deterioration, spalling, settlement, and surface disintegration.

VI. OBSERVATION AND FINDINGS OF FIELD INVESTIGATION

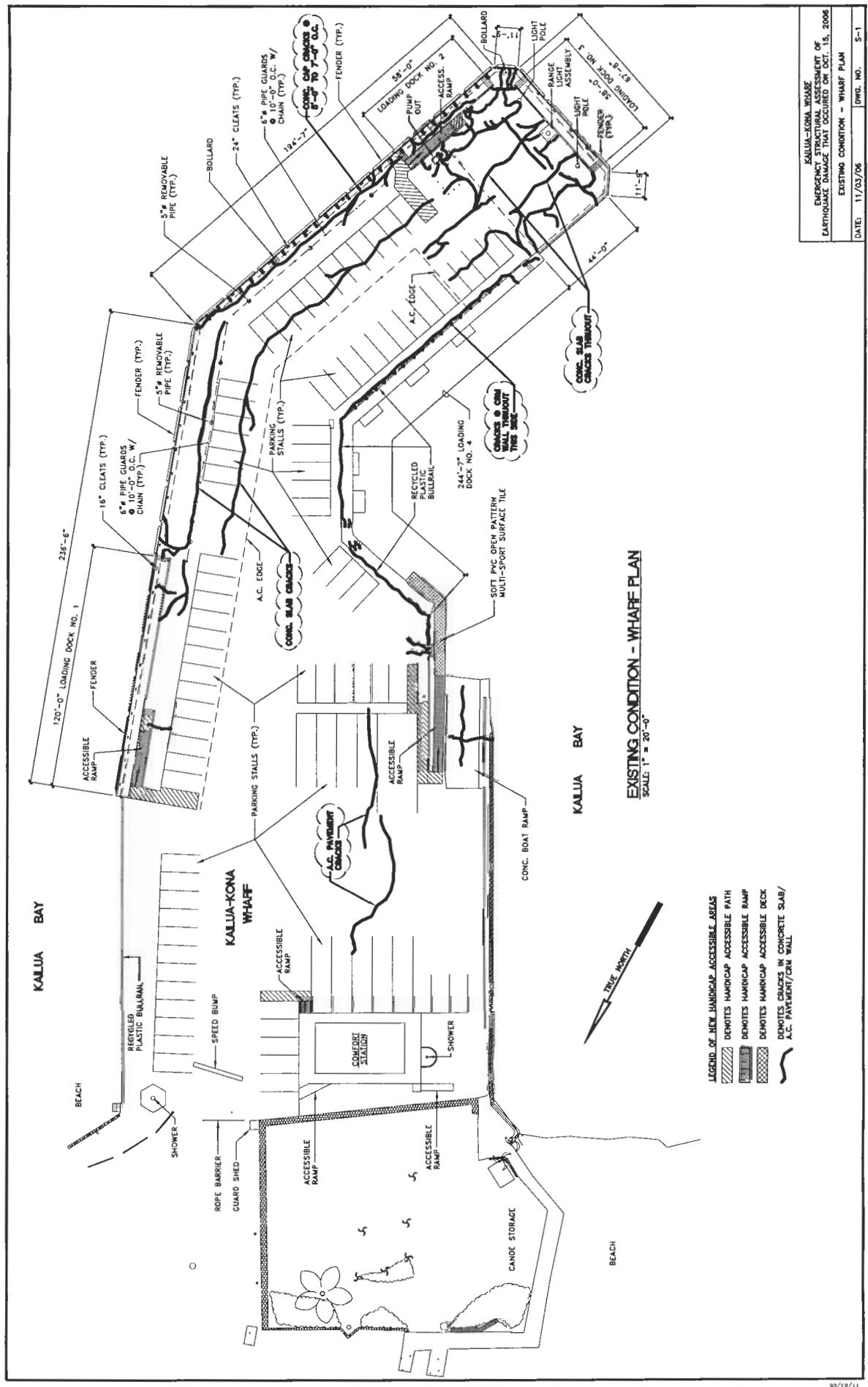
1. Underwater Investigation:

Sheet Pile Bulkhead:

- A. Steel Sheet Pile for the Bulkhead - Steel sheet piles itself are in good condition. There are numerous areas of the steel sheet pile surface that the surface rust and marine growth had fallen off due to the bending and movement of the steel sheet pile from the earthquake.
- B. Concrete Cap for Steel Sheet Pile Bulkhead - The concrete cap (2'-2" thick by 9'-6" deep) which protect the steel sheet pile bulkhead and reinforcing bars from the salt water have vertical cracks through the cap. The concrete cap are cracked along the length of the steel sheet pile bulkhead wall. The cracks run from the top of the cap to the bottom of the cap. The concrete cap supports and strengthens the top of the steel sheet pile bulkhead with a tie back system. The concrete cap also protects the steel sheet pile bulkhead and reinforcing bars from salt water corrosion. The cracks were caused by the recent earthquake on October 15, 2006.
- C. Rock Revetment - The revetment is in good conditions.

2. Above water Investigation:

- A. Concrete Cap for Steel Sheet Pile Bulkhead - Concrete cap along the length south east side of the wharf have many cracks. Cracks run the full height and through the caps. The cracks are about 5'-0" to 7'-0" apart along the length of the east side bulkhead wall. See photos.
- B. Concrete Slab on Grade - There are many cracks throughout the concrete slab on grade. The crack are up to 3/32" wide. Most of the damage slab occurred at the south end of the wharf. See photos.
- C. A.C. Pavement - There are some cracks on the A.C. pavement at the north end of the wharf parking area. See photos.
- D. CRM Wall - The CRM retaining wall have many cracks along the wall. The CRM wall is located on the west side of the wharf. See photos.
- E. Concrete Loading Dock - Concrete loading docks No. 2 and No. 4 have cracks on the slab and stairways. See photos.
- F. Boat Launching Ramp - Boat ramp has cracks on the slab. See photos.



LEGEND OF NEW HANDICAP ACCESSIBLE AREAS

	DENOTES HANDICAP ACCESSIBLE PATH
	DENOTES HANDICAP ACCESSIBLE RAMPS
	DENOTES HANDICAP ACCESSIBLE DECKS
	DENOTES CRACKS IN CONCRETE SLABS A.C. PAYMENT/CRA WALL

PHOTOGRAPHS

ABOVE WATER CONDITION OF EXISTING WHARF



9

Loading Dock No. 1 -
East Side (Looking North)



10

Loading Dock No. 2 -
South East Side



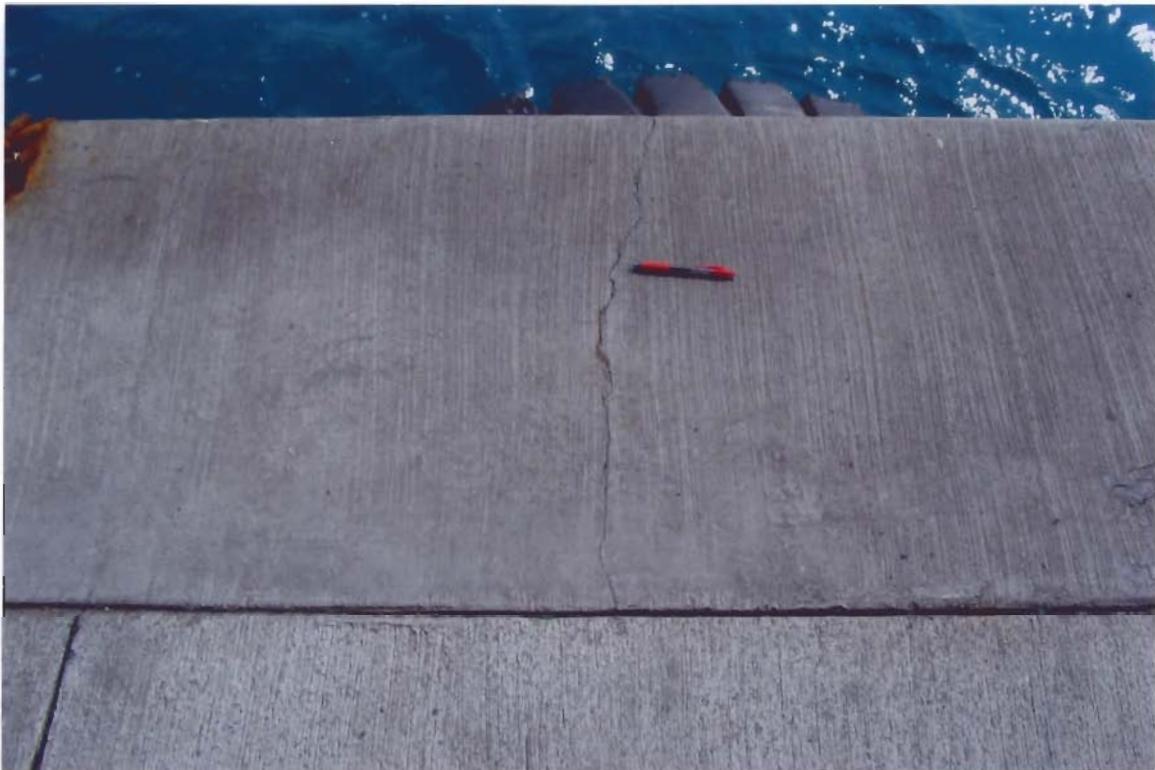
11

Wharf - South End (Looking North)



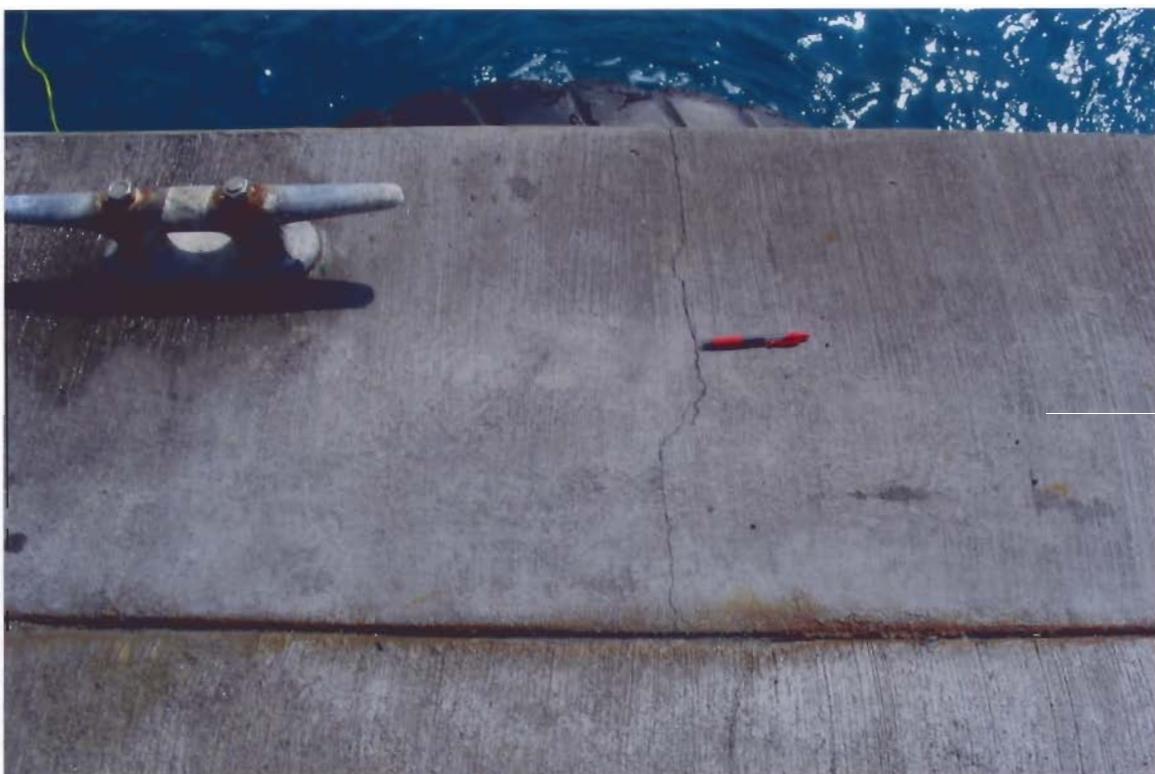
12

West Side Loading Dock
No. 4 (Looking North)



13

South East Side -
Typical cracks at pile caps



14

South East Side -
Typical cracks at pile caps



15

South East Side -
Typical cracks at pile caps



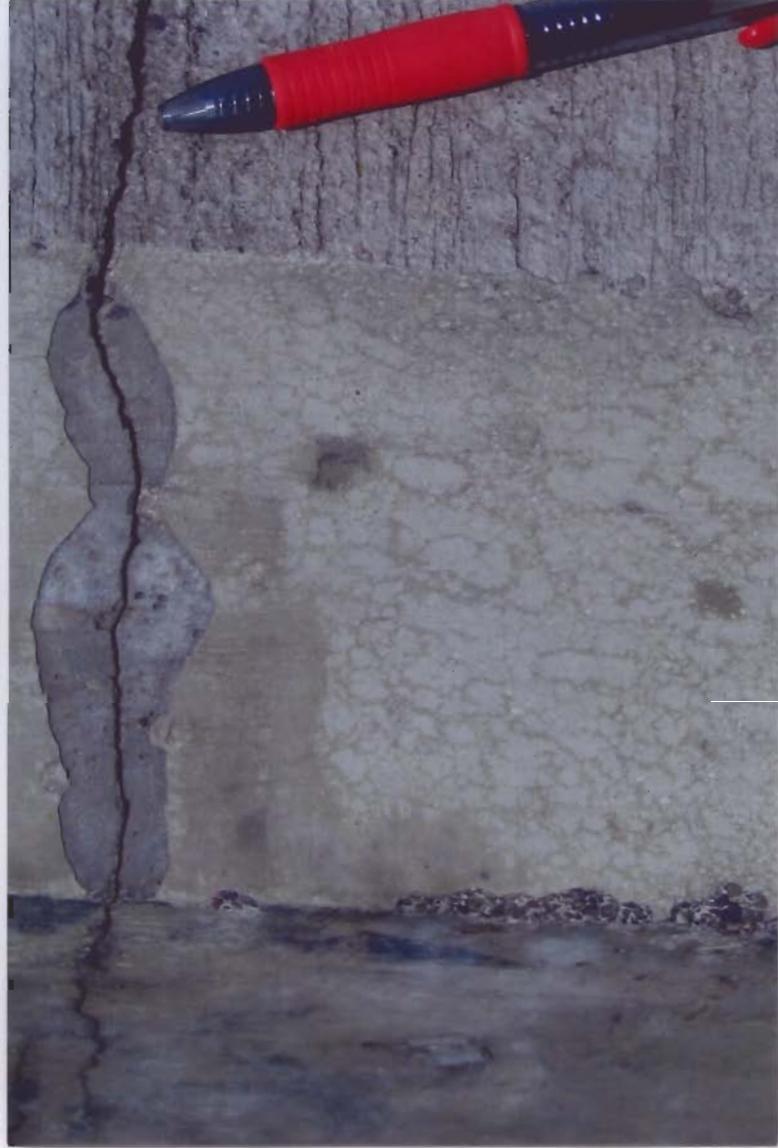
16

South East Side -
Typical cracks at pile caps



17

South East Side -
Typical cracks at pile caps



18

Typical cracks at
pile caps





19

East Side - Typical cracks on deck slab throughout

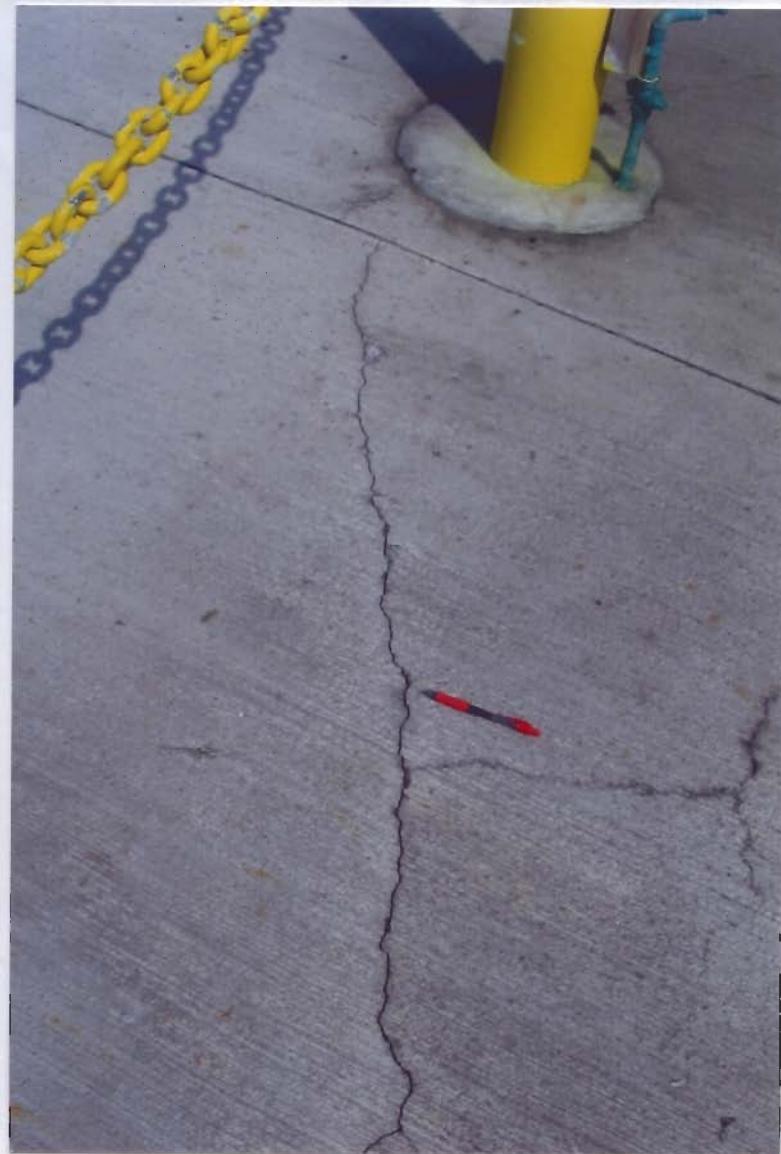


20

Close-up view of
cracks on deck
slab



21 East Side - Typical cracks on deck slab throughout



22 Close-up view of crack deck slab



23 East Side - Cracks on deck slab throughout



24

Cracks on slab landing at
Loading Dock No. 2



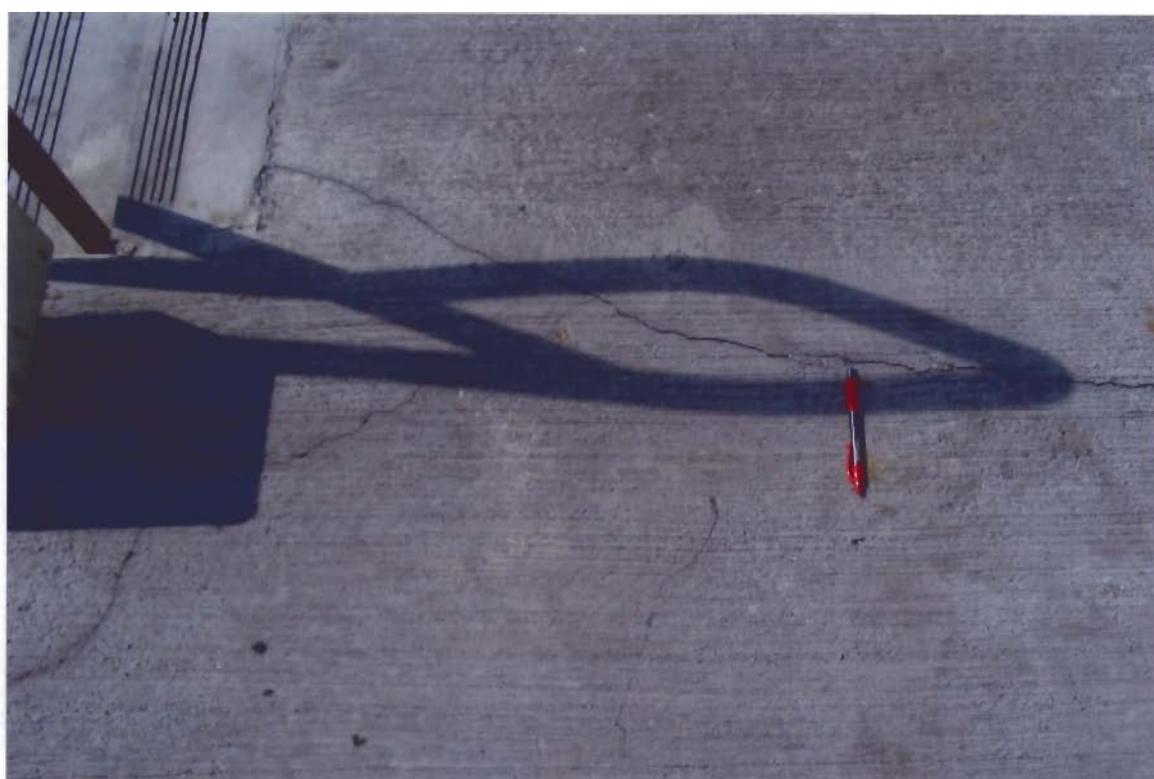
25

Loading Dock No. 2 -
Cracks on deck slab area



26

Loading Dock No. 2 - Typical
slab cracks at landing throughout



27

Loading Dock No. 2 -
Typical slab cracks at landing



28

Stairway at Loading Dock No. 2 -
Cracks at stair threads



29

Stairway at Loading Dock No. 2 -
Cracks at stair threads



30

South End - Cracks on slab
throughout deck area



31

South End - Cracks on slab
throughout deck area



32

South End - Typical cracks at
deck slab throughout



33

South End - Close-up view of typical
cracks on deck slab



34

South End - Cracks on
deck slab throughout area



35

South End - Close-up view
of cracks on slab



36

South End of Wharf -
Typical cracks on slab
throughout deck area



37

Close-up view of cracks
on slab area



38

Close-up view
of cracks on
slab area



39 South End - Cracks on deck slab



40 South End - Cracks on deck
slab throughout



41

South End - Typical cracks throughout on deck slab



42

South End - Cracks on deck slab



43

South West Side - Typical cracks
on slab deck area throughout



44

South West Side - Close-up
view of cracks on slab



45

South Side - Cracks on slab
throughout deck area



46

South End - Close-up
view of cracks on slab



47

North West Side -
Cracks at A.C. pavement



48

North West Side -
Cracks at A.C.
pavement





49

West Side
Stair/Landing
cracks @
Loading Dock
No. 4



50

Stair cracks @
Loading Dock No. 4



51

Stair landing @ Loading
Dock No. 4 - Cracks on wall



52

Stairway/Landing @ Loading Dock
No. 4 - Cracks at stairway



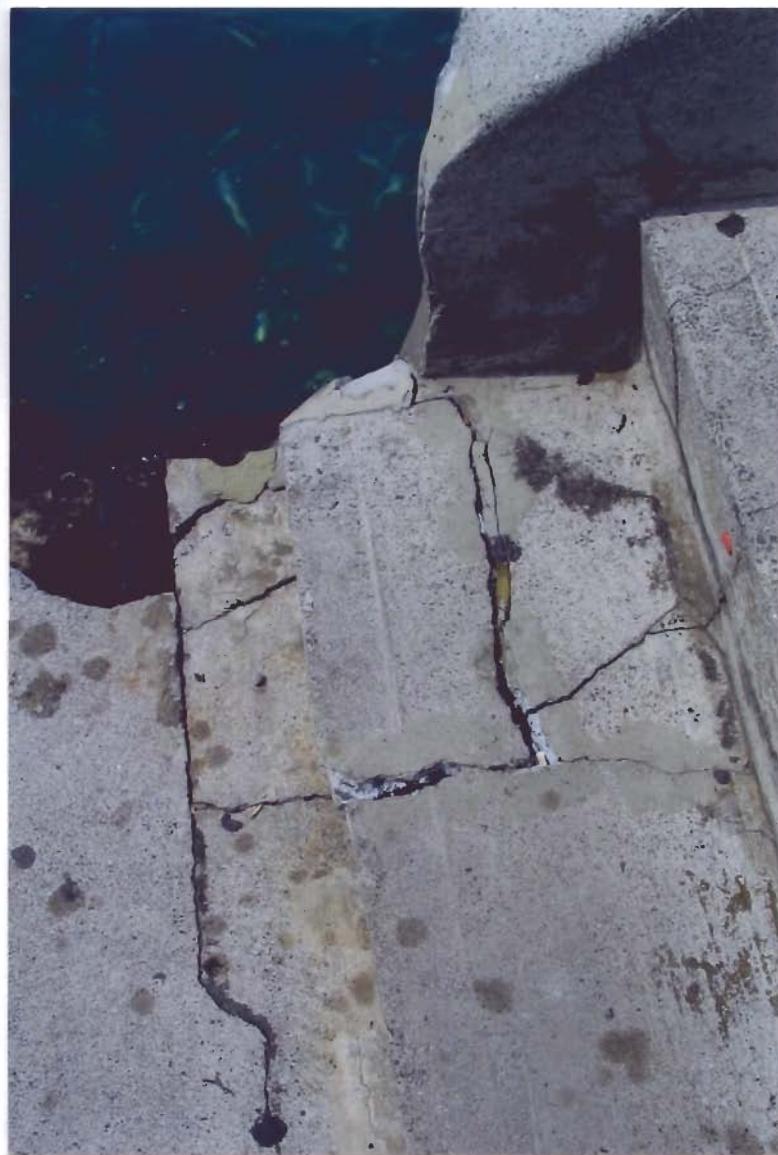
53

Stairway/Landing @ Loading Dock
No. 4 - Cracks at stairway



54

Cracks - Stairway @
Loading Dock No. 4



55

Cracks - Stairway @
Loading Dock No. 4



56 Loading Dock No. 4 -
Slab cracks throughout



57 Loading Dock No. 4 -
Slab cracks throughout



58

Loading Dock No. 4 -
Slab cracks throughout



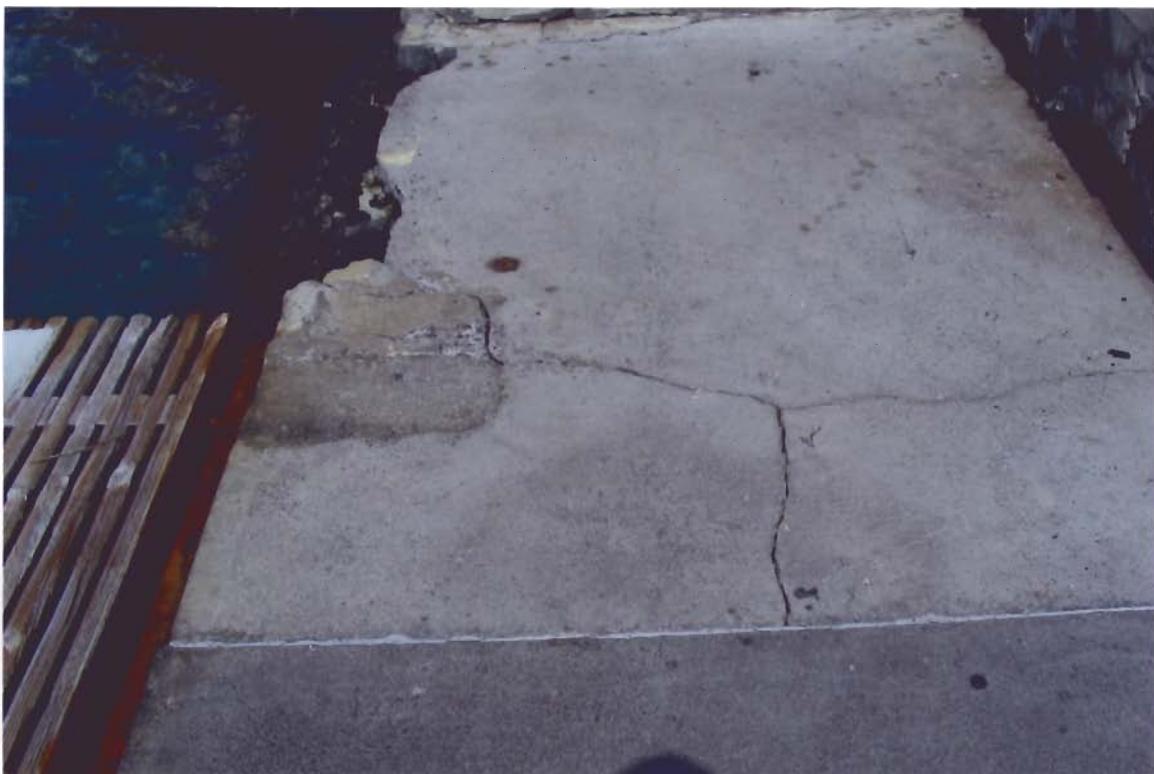
59

Loading Dock No. 4 -
Slab cracks throughout



60

Loading Dock No. 4 -
Slab cracks throughout



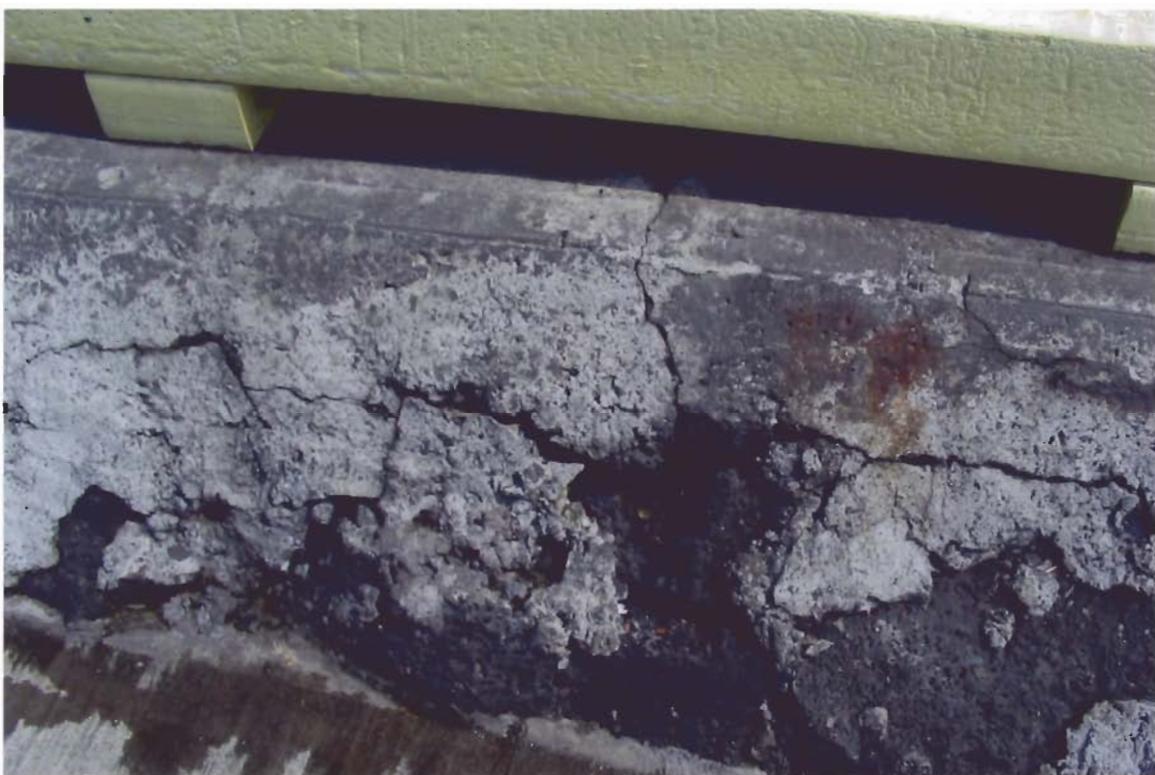
61

Loading Dock No. 4 -
Slab cracks throughout



62

Crack CRM walls throughout
along Loading Dock No. 4



63

Crack CRM walls throughout
along Loading Dock No. 4



64

Crack CRM walls throughout
along Loading Dock No. 4



65

Crack CRM walls throughout
along Loading Dock No. 4



66

Crack CRM walls throughout
along Loading Dock No. 4



67

Crack CRM walls throughout
along Loading Dock No. 4



68

Crack CRM walls throughout
along Loading Dock No. 4



69

Crack CRM walls throughout
along Loading Dock No. 4



70

Crack CRM walls throughout
along Loading Dock No. 4



71

Crack CRM walls throughout
along Loading Dock No. 4



72

North West Side of Wharf -
Crack slabs at Boat Launching
Ramp

PHOTOGRAPHS

UNDERWATER CONDITION OF EXISTING
STEEL SHEET PILE BULKHEAD



73

Typical steel sheet pile bulkhead

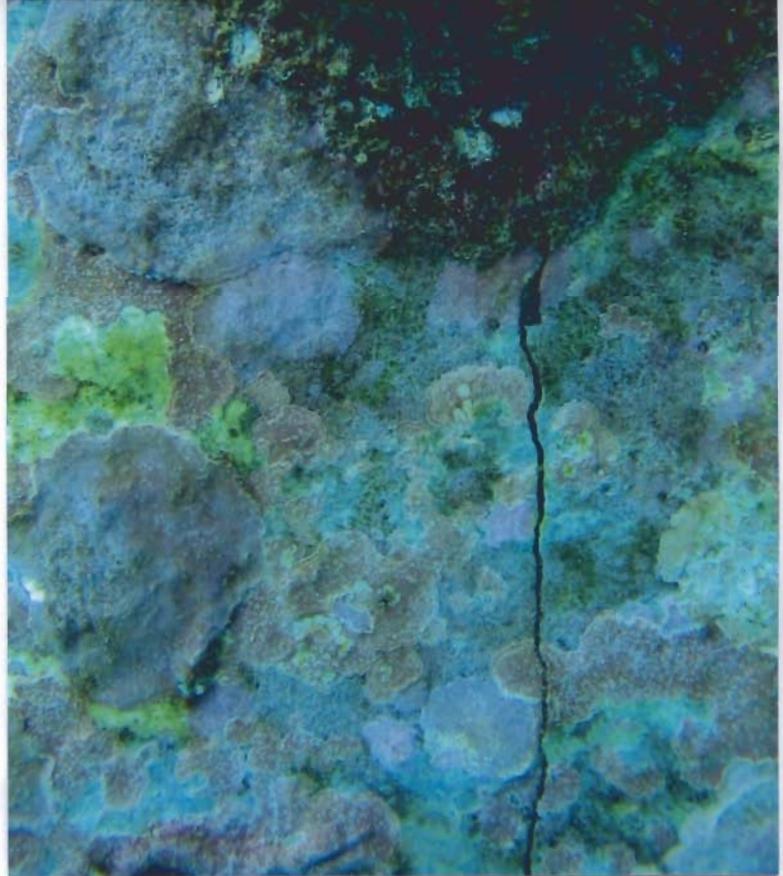
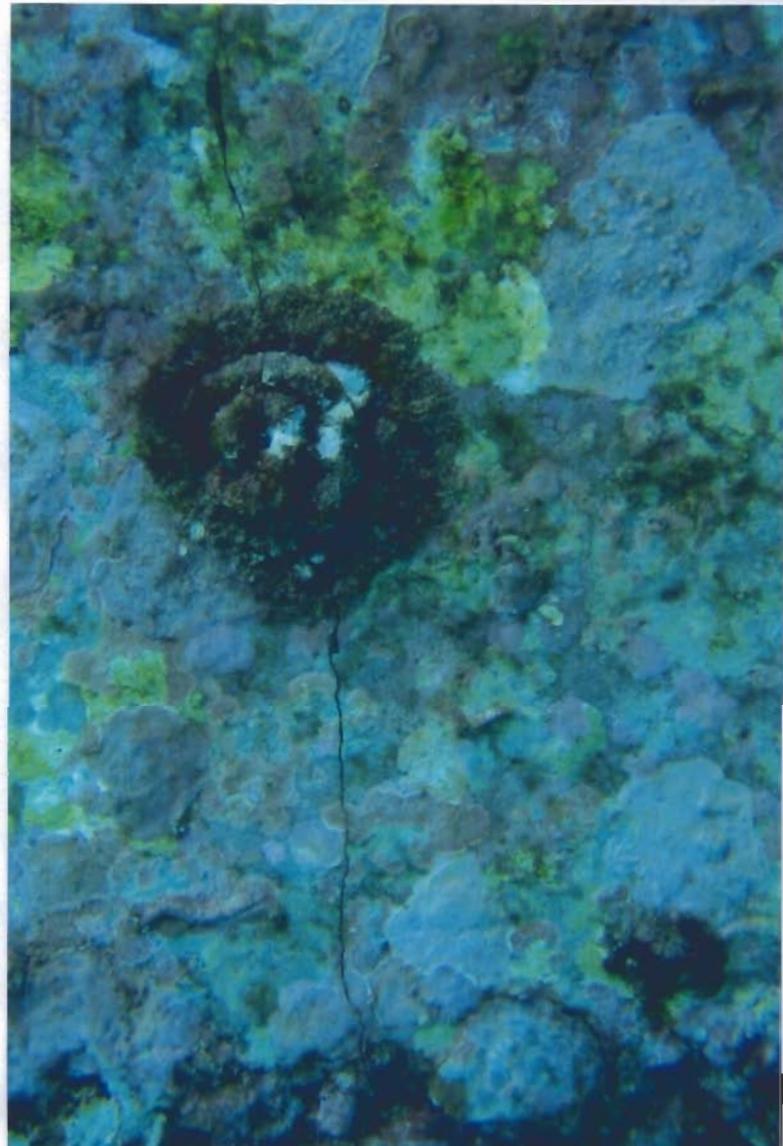


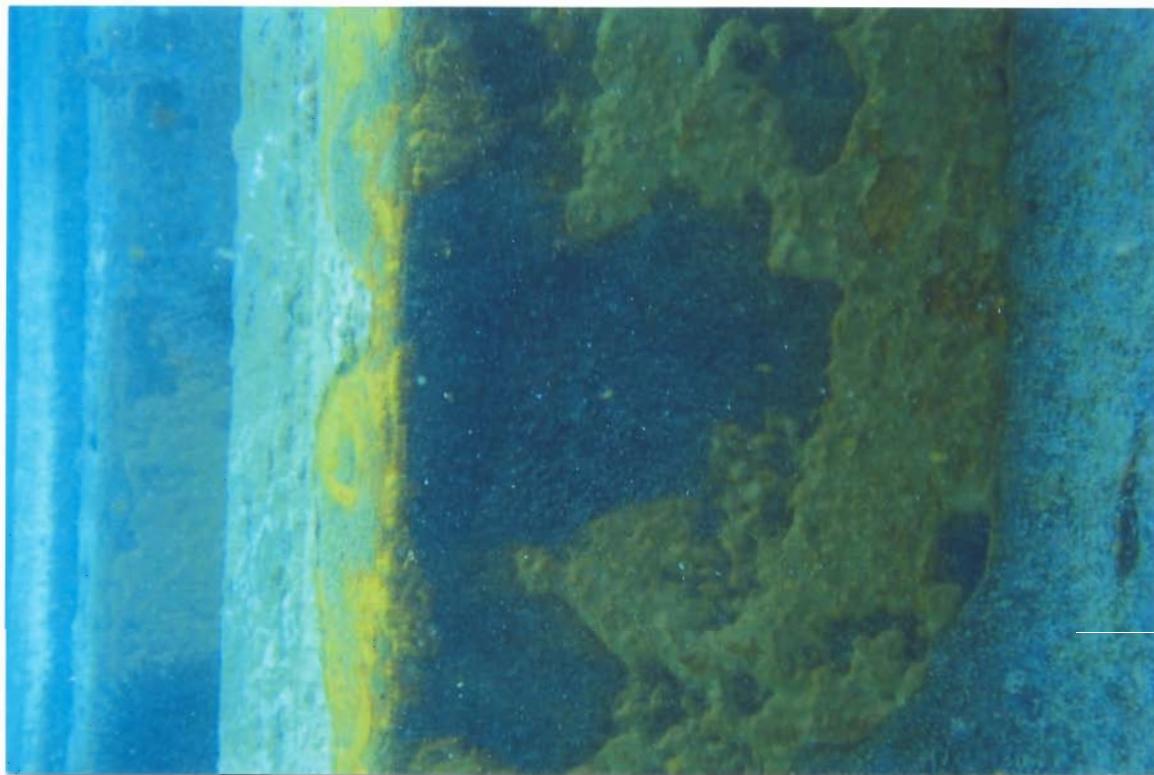
74

Sheet pile bulkhead - Concrete cap bottom

75

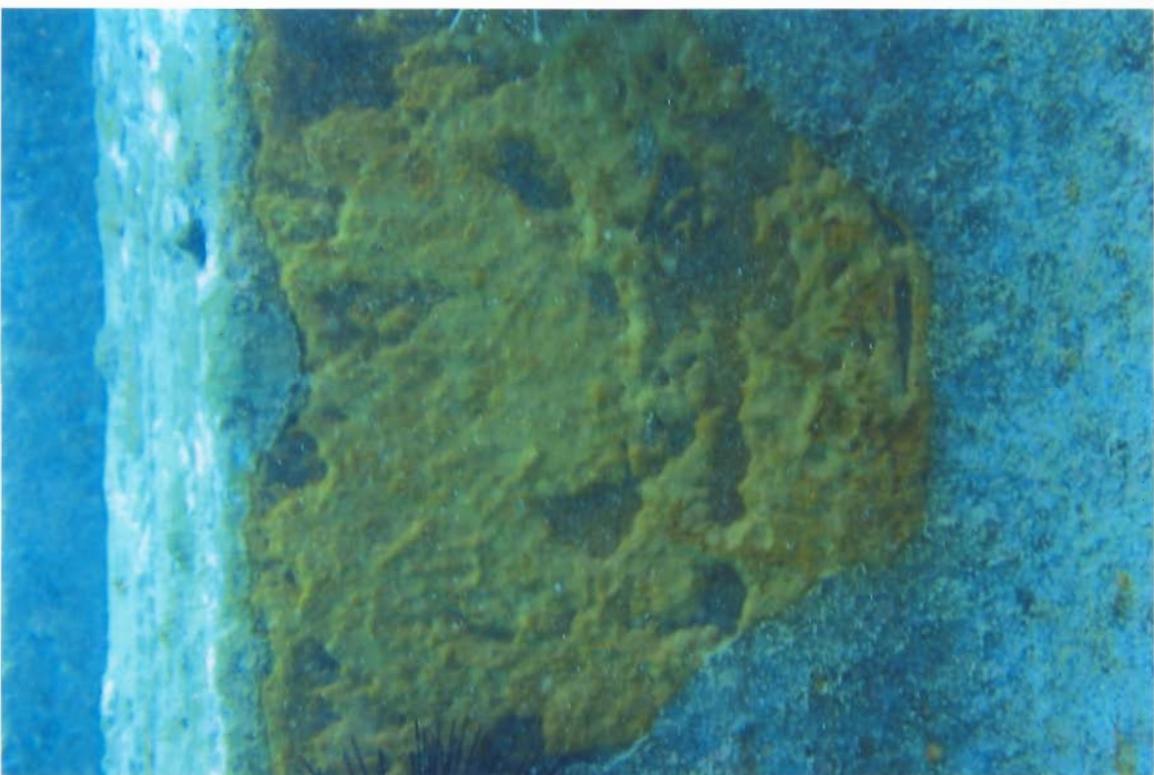
Typical vertical cracks at sheet pile concrete caps.





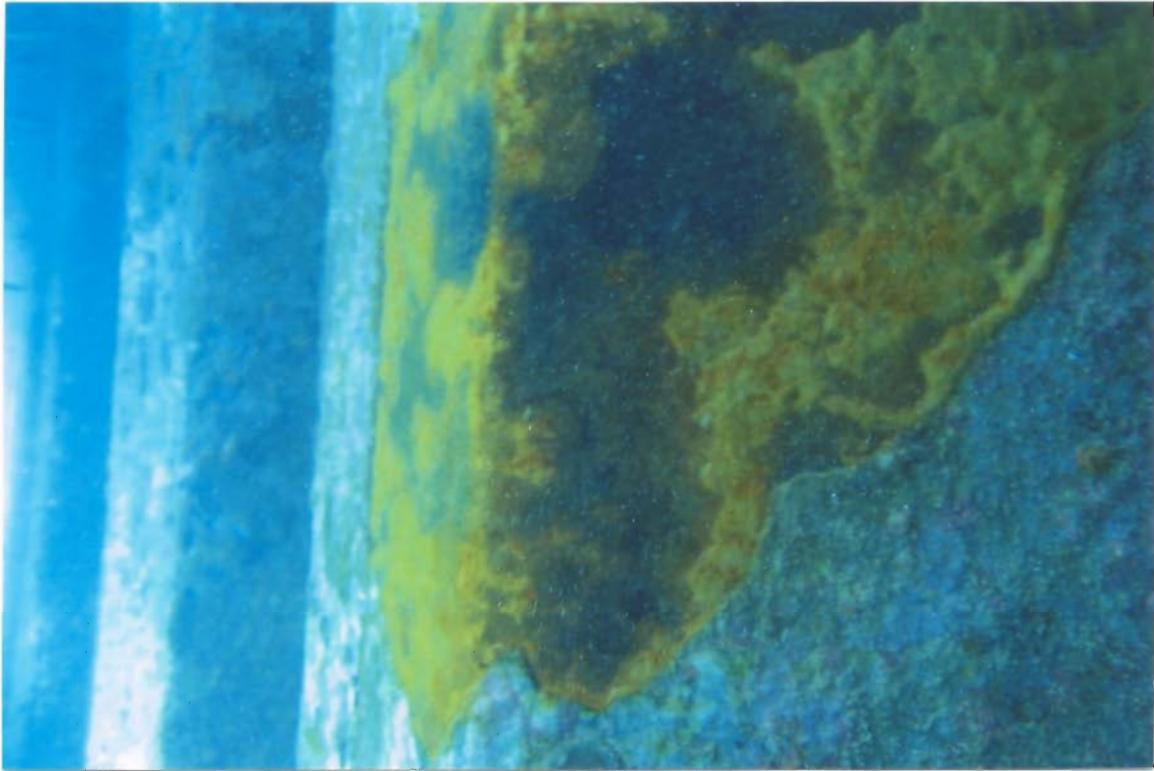
76

Typical steel sheet pile - Area of rusted and marine growth surface layer dislodge and separated from the face of the sheet pile due to impact and bending of the sheet pile from the earthquake forces.



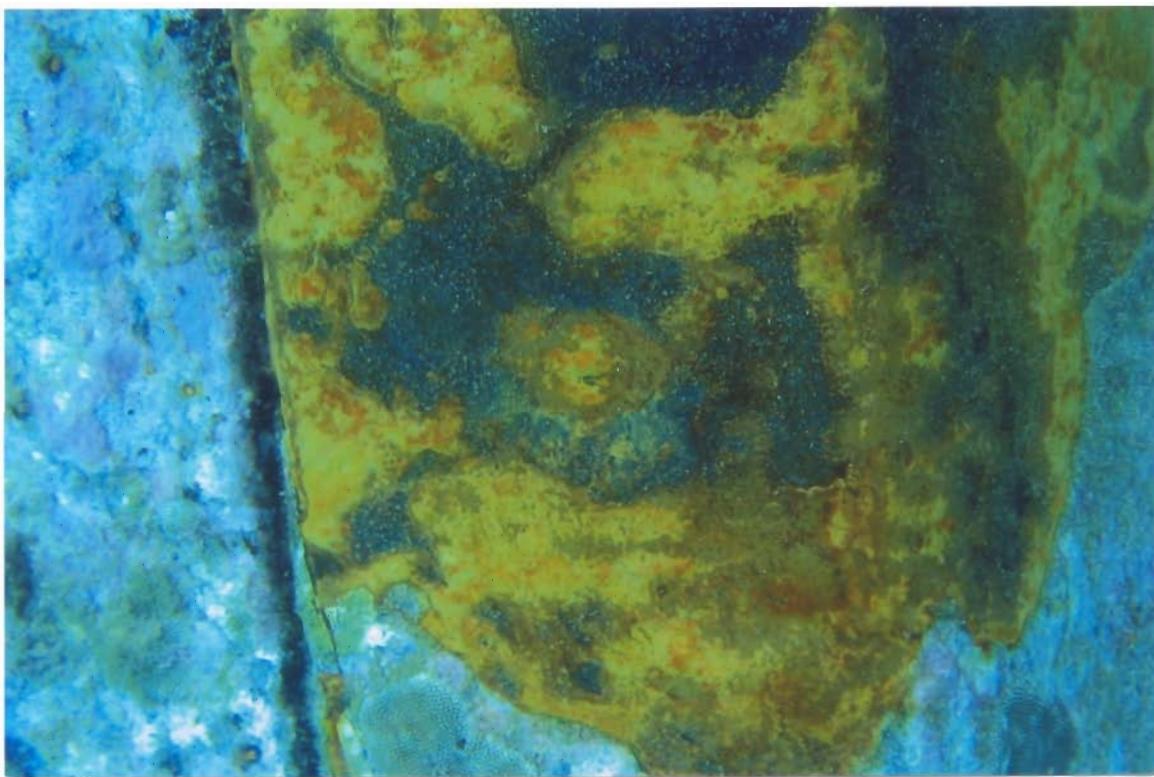
77

Steel sheet pile - Area where rusted surface dislodge and separated from the face of the sheet pile.



78

Steel sheet pile - Area where rusted surface dislodge
and separated from the face of the sheet pile.



79

Steel sheet pile - Area where rusted surface dislodge
and separated from the face of the sheet pile.

VII. ORDER OF MAGNITUDE ESTIMATED DESIGN AND CONSTRUCTION COST
ESTIMATE TO REPAIR EARTHQUAKE DAMAGES TO KAILUA - KONA WHARF

ORDER OF MAGNITUDE ESTIMATED DESIGN AND CONSTRUCTION COST ESTIMATE

Submitted By: Arnold T. Okubo and Associates, Inc.

Date: 11/01/06

Project: Kailua - Kona Wharf,
Kailua - Kona, Hawaii

Sheet 1 of 1

**Emergency Structural Assessment of
Earthquake Damage to Kailua - Kona Wharf - 0% Design**

	Item Description	Quantity		Estimated Construction Cost	
		Number	Unit	Unit Cost	Total
1)	Mobilization & Demobilization	Job	L.S.	\$	50,000
2)	Repair Conc. Pile Caps for Sheet Pile Bulkhead	40	EA.	5,000	200,000
3)	Repair Cracks in Pavement Slab	2000	L.F.	175	350,000
4)	Loading Dock No. 2 Repair Stairway & Cracks on Slab	Job	L.S.	L.S.	40,000
5)	Loading Dock No. 4 Repair Stairway & Cracks on Slab	Job	L.S.	L.S.	200,000
6)	Repair CRM Retaining Wall at Loading Dock No. 4	300	L.F.	200	60,000
7)	Repair Boat Ramp Slab	Job	L.S.	L.S.	100,000
8)	Repair A.C. Pavement	Job	L.S.	L.S.	<u>25,000</u>
				Sub-Total	\$ 1,025,000
					<u>205,000</u>
				20% Contingencies	
					\$ 1,230,000
					175,000
					60,000
				Total Estimated Construction Cost	\$ <u>1,465,000</u>

VIII. CONCLUSION AND RECOMMENDATIONS

The damages caused by the October 15, 2006 earthquake are recommended to be repaired for health and safety issues and to protect the structure from future earthquake and accelerated deterioration.

The following crack and damage structures are recommendations for repair due to earthquake damages:

1. Concrete Caps for Sheet Pile Bulkhead.
2. Concrete Slab on Grade.
3. Concrete Stairway and Landings at Loading Dock.
4. Concrete Slabs at Loading Docks No. 1 and No. 4.
5. CRM Retaining Walls.
6. Concrete Slab at Boat Launching Ramp.

The order of magnitude estimated design and construction cost estimate to repair the earthquake damages are \$ 1,465,000.00.